

ERRATUM

Page 15. Figure 8. Photograph is upside down.

Page 27. III should read - Nets used (by Fanny Bay Oyster Company) to harvest oysters.

A PACIFIC OYSTER STAKE CULTURE PILOT PROJECT
IN BRITISH COLUMBIA

by

W. E. Lorne Clayton and T. T. Pobran

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Stake cultured oysters, *Crassostrea gigas*,
after fifteen months growth.
Measured length 80.2 mm.

ABSTRACT

In 1978 a pilot project was established at Mud Bay on the east coast of Vancouver Island, British Columbia, to determine the feasibility of commercially producing Pacific oysters in an area which is marginal for traditional beach culture by using a stake culture technique. The study site was characterized by good water flow, a soft substrate, a dense population of eel grass and excessive exposure to wave and wind action which constantly moved shellstock up to the 4 to 5 metre tide level. The average cultch produced 235.72 ml (8.3 ounces) of oyster meat in 22 months. At one cultch per stake and 9 stakes per square metre, this is equivalent to a yield of 21,206 litres per hectare (1908 gallons/acre). The low mean volume of 18.7 ml (.66 ounces) per oyster was attributed to the high original spat count (68.3 spat/cultch) which resulted in severe overcrowding. The final meat product was lighter coloured and sweeter flavoured than that produced by bottom culture in the same area. The exposure problem was all but eliminated. Production costs were \$1.12 per litre (\$4.23/gallon) unshucked, based on a minimum wage at the time of \$2.75 per hour. Stake culture allows the productive use of marginally suitable foreshore and reduces the effects of predation and competition.



CONTENTS

	<u>Page</u>
ABSTRACT	ii
CONTENTS	iii
LIST OF FIGURES	iv
LIST OF TABLES	v
ACKNOWLEDGEMENTS	vi
INTRODUCTION	1
BACKGROUND	2
SITE AND EXPERIMENTAL DESIGN	3
GROWTH RATE	9
MAINTENANCE OF STAKE CULTURE	12
MORTALITY	16
HARVESTING	18
PROCESSING	19
PRODUCTION	20
COSTS	22
CONCLUSION	24
ADDENDUM	25
REFERENCES CITED	26
APPENDICES	27
Appendix I	28
Appendix II	29
Appendix III	30



LIST OF FIGURES

	<u>Page</u>
Figure 1. Map showing the location of Mud Bay, British Columbia	4
Figure 2. The location of stake and ground plots within Mud Bay, British Columbia	5
Figure 3. Stake hole puncher in use	6
Figure 4. Pattern and density used in planting stakes	6
Figure 5. Oyster seed from Pendrell Sound on Pacific oyster cultch	7
Figure 6. Location of Pendrell Sound Provincial Shellfish Reserve, British Columbia	8
Figure 7. Mean shell length of oysters grown at two tide levels (upper and lower) between April, 1978, and February, 1980, at Fanny Bay, British Columbia	11
Figure 8. Destruction of oyster stakes by <i>Bankia setacea</i>	15
Figure 9. Mean oyster mortality rates of stake and ground plots	17

LIST OF TABLES

	<u>Page</u>
Table 1. Mean increase in length of shell in mm by sampling intervals. No data is available for the ground plot from May 16/79 to February 12/80 because of "washout"	10
Table 2. Number of cultch and/or stakes washed away or knocked down during study	14
Table 3. Volume of meat determined for size classes from each plot	21
Table 4. Cost to produce and harvest stake cultured oysters	23



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INTRODUCTION

There are approximately 1215 hectares (3000 acres) of good oyster culturing foreshore in British Columbia with a commercial production capability of approximately 2300 litres per hectare (250 U. S. gallons/acre). Most of this good oyster producing foreshore in the Province has already been leased to oyster culturists or alienated for other uses.

It is estimated that there exists on the British Columbia coast an equal amount of marginal oyster culturing foreshore with a production capability of less than 1000 litres per hectare (100 U. S. gallons/acre). The purpose of this study is to determine if the marginal areas can be brought up to commercial standards by the use of a near-bottom stake culture technique.

BACKGROUND

The near bottom technique of culturing bivalves, primarily oysters and mussels, on stakes is not a recent innovation. Many countries use such culture methods, modified to suite local geographic conditions, available construction materials and labour costs. In France, for example, the Bouchot system utilized stakes (poles) approximately 3 metres high, from which bags or ropes with mussels attached were hung (Iversen, 1976). In New Zealand, Cuba, Italy, the Philippines, Spain, North America, and on the Ogiku Peninsula in Japan, stakes are used either separately or collectively as racks for growing oysters (Iversen, 1976; Koringa, 1976). In the 1950's, Dr. Dan Quayle, of the British Columbia Provincial Government, experimented with "stick" culture in Ladysmith Harbour. Although these studies suggested the benefits of such a technique, at the time this project was initiated no commercial stake culture operations were being used in the Province.

Muddy beach areas contain large amounts of inorganic debris which a bottom cultured oyster must actively separate from the food particles which it ingests. The process of raising the animal off of the bottom places the oyster in an environment with a greater ratio of food to debris particles, thus, feeding becomes more efficient. It is assumed that this advantage is reflected in faster growth of the oyster with an overall greater meat production per area under cultivation.

Other advantages of the stake culture technique include reduced space competition with eel grass (*Marina zostera*) and sea lettuce (*Ulva* spp.), decreased predation from shore and rock crabs (*Hemigrapsus* spp. and *Cancer productus* respectively) and starfish (primarily *Pycnopodia helianthoides* and *Piaster ochraceus*), and elimination of the movement of shellstock in areas of high wind and wave exposures.

SITE AND EXPERIMENTAL DESIGN

A project site was established on a commercial lease operated by Fanny Bay Oyster Company¹ in Mud Bay on Baynes Sound located between Vancouver and Denman Islands (Figure 1).

The project site was selected for its easy access, soft substrate, good water flow, and because of problems the company was experiencing with high winds, wave exposure and interspecific competition.

Three plots were established by technicians in April of 1978 (Figure 2), prior to involvement of the authors. Stake plot "A" was located at the 1 meter tide level and contained 1270 stakes. Stake plot "B" was located at the 1.3 metre tide level and contained 995 stakes. A bottom control plot was established at the 1.3 metre tide level.

The stakes used for this study were of local untreated red cedar cut to approximately 45 cm x 2.5 cm x 2.5 cm, into each of which was driven a 5.7 cm (2½ in.) galvanized nail. Planting of the stakes into the intertidal substrate was facilitated by a "stake puncher" (Figure 3, Appendix 1). The stakes were planted approximately 22 cm into the substrate, leaving 23 cm exposed. Planting the stakes 30 cm apart provided a density of 500 stakes per 100 m² (Figure 4).

The oyster seed utilized in this project was collected on Pacific oyster cultch (Figure 5) from Pendrell Sound Provincial Shellfish Reserve, (Figure 6). The seed was held in the intertidal zone until the stakes were planted in April, 1978, at which time each individually punched cultch was set over the nail of the stake. The cultch were placed concave side down to prevent the "cup" from being filled with silt (Appendix 2).

¹Fanny Bay Oyster Company, P. O. Box 209, Fanny Bay, B. C. VOR 3B0

Figure 1. The location of Mud Bay, on Vancouver Island, British Columbia.

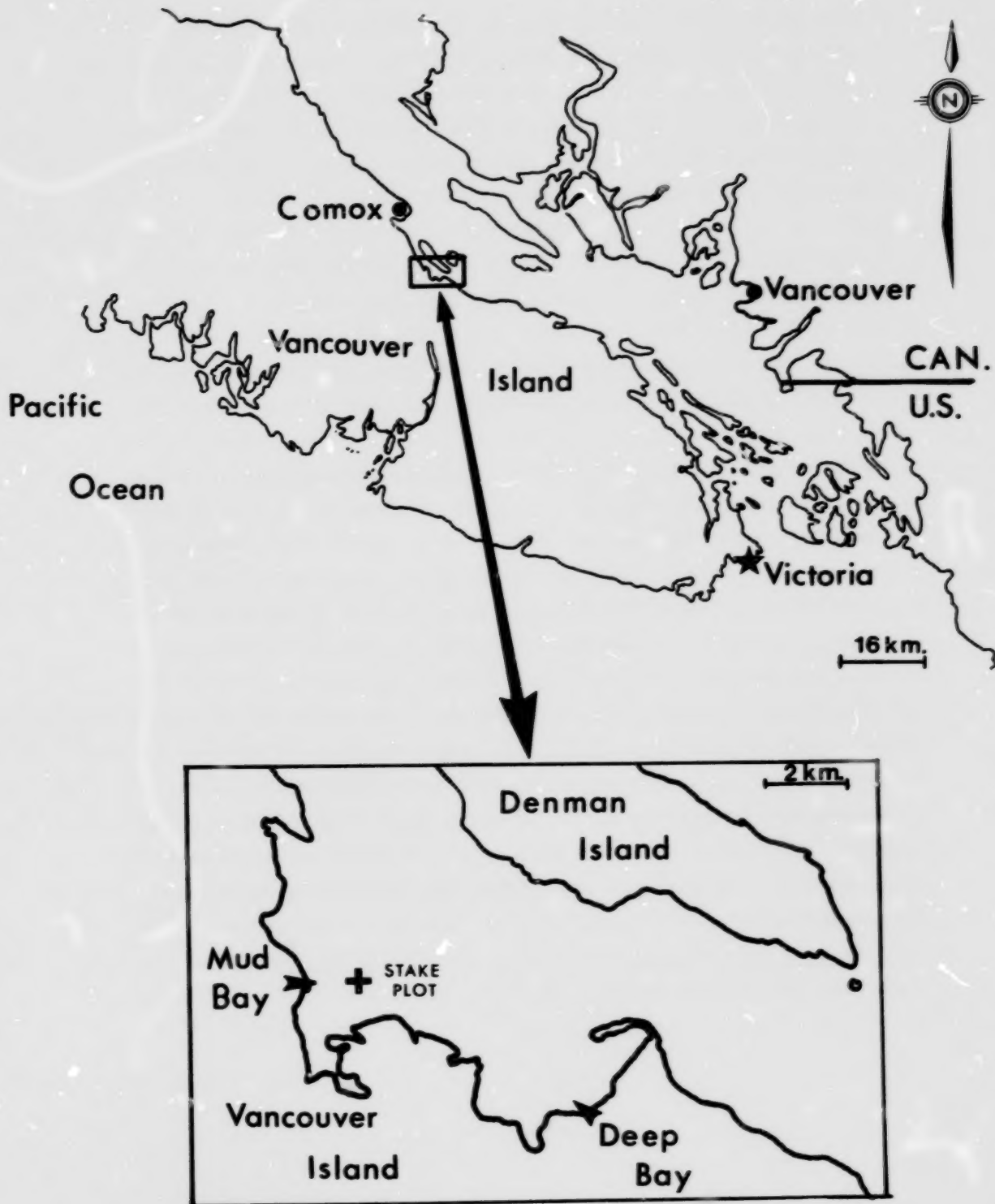


Figure 2. The location of the stake and ground plots within Mud Bay, British Columbia.

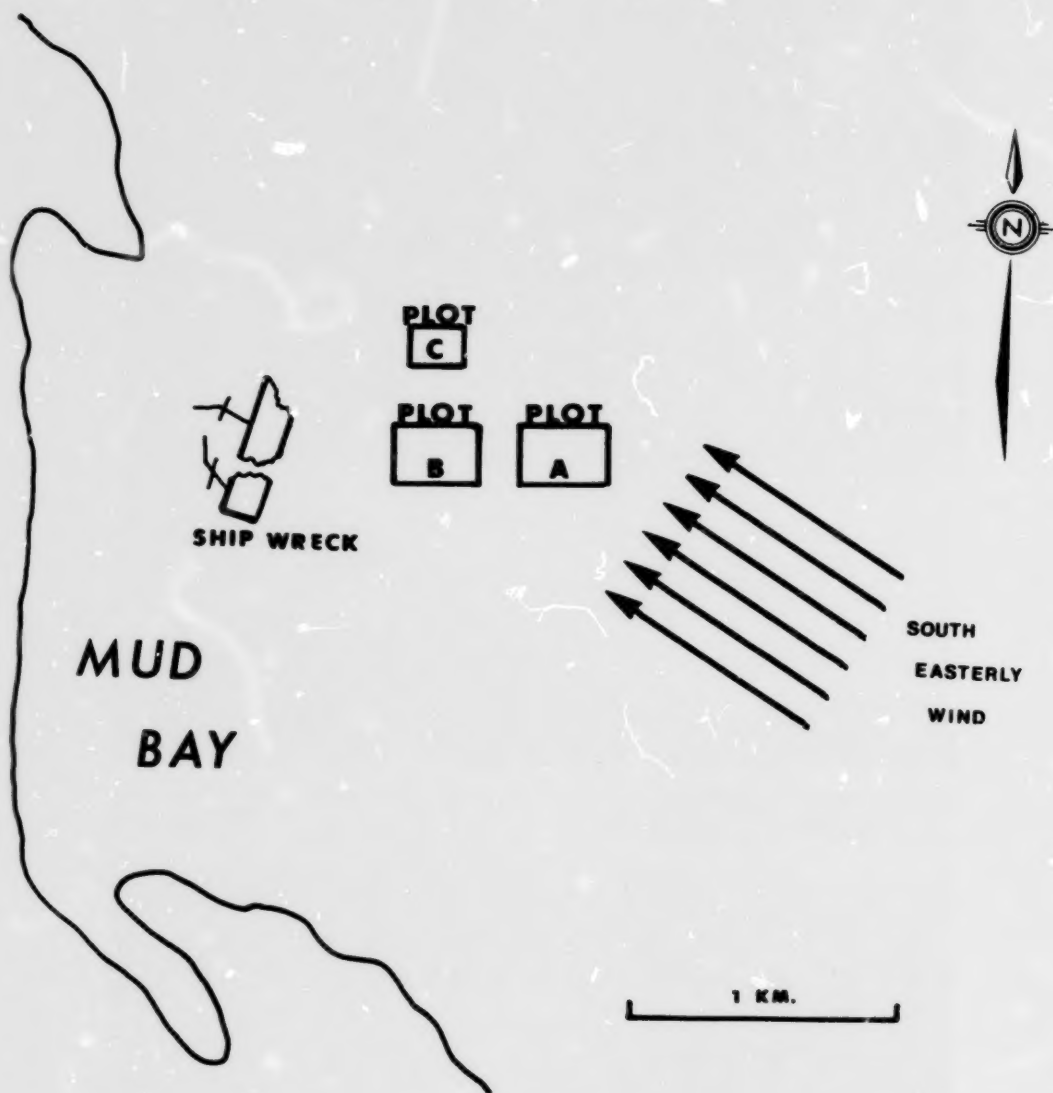


Figure 3. Stake puncher in use.

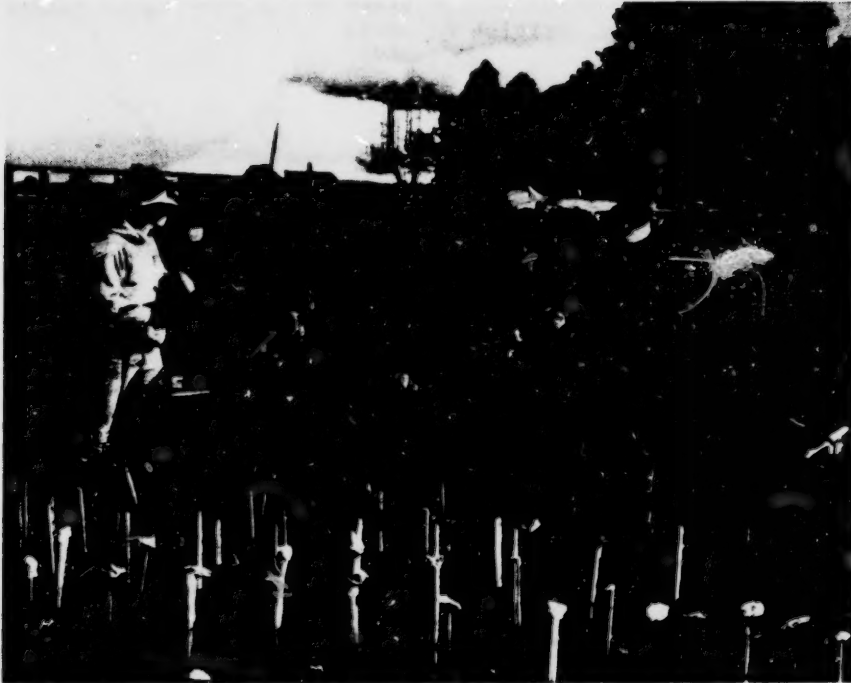


Figure 4. Pattern and density used in planting stakes.



Figure 5. Oyster seed from Pendrell Sound on Pacific oyster cultch, approximately 9 months old.

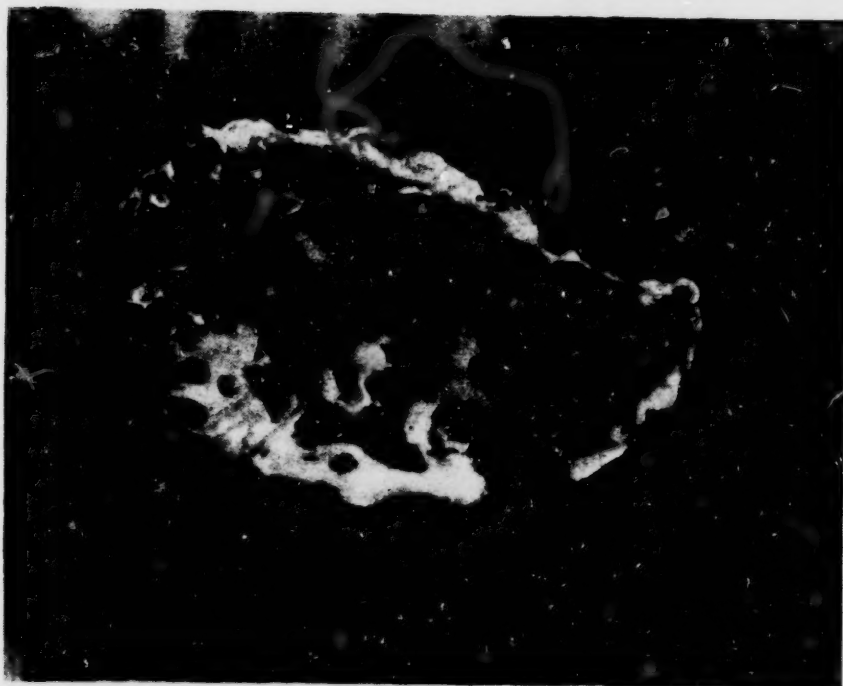
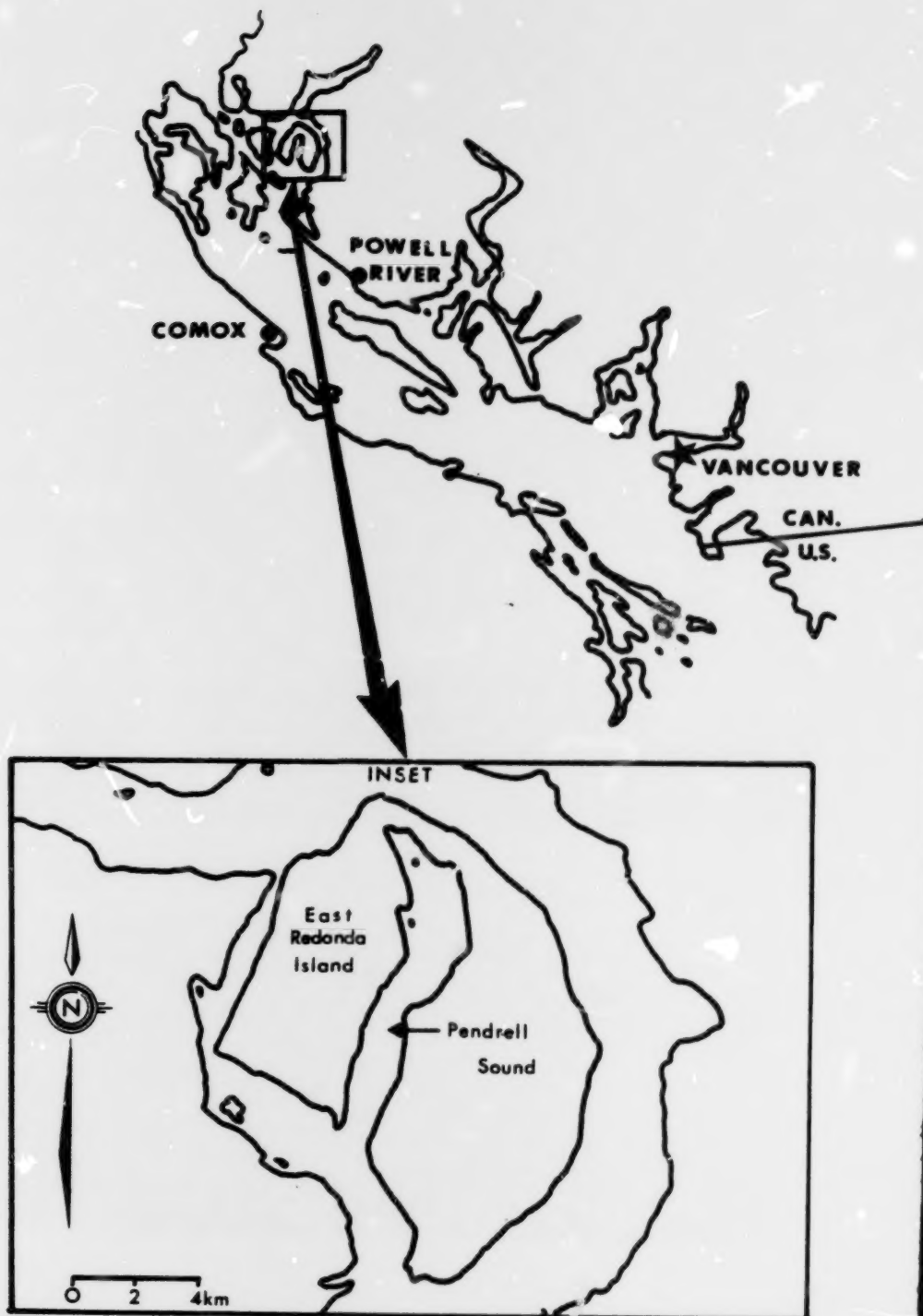


Figure 6. Map showing the location of Pendrell Sound Provincial Shellfish Reserve, British Columbia.



GROWTH RATE

The oyster growth rate of the stake and ground plots was measured every three months for a period of 22 months from planting to harvest. The measurement recorded was the length (anterior-posterior) of the individual oysters. Overcrowding made depth and width measurements of the shell impossible to record.

Table 1 outlines growth rates of oysters in specific plots. Records for the ground cultured oysters in plot C are available for only a six month period as these oysters were washed away during the stormy winter season.

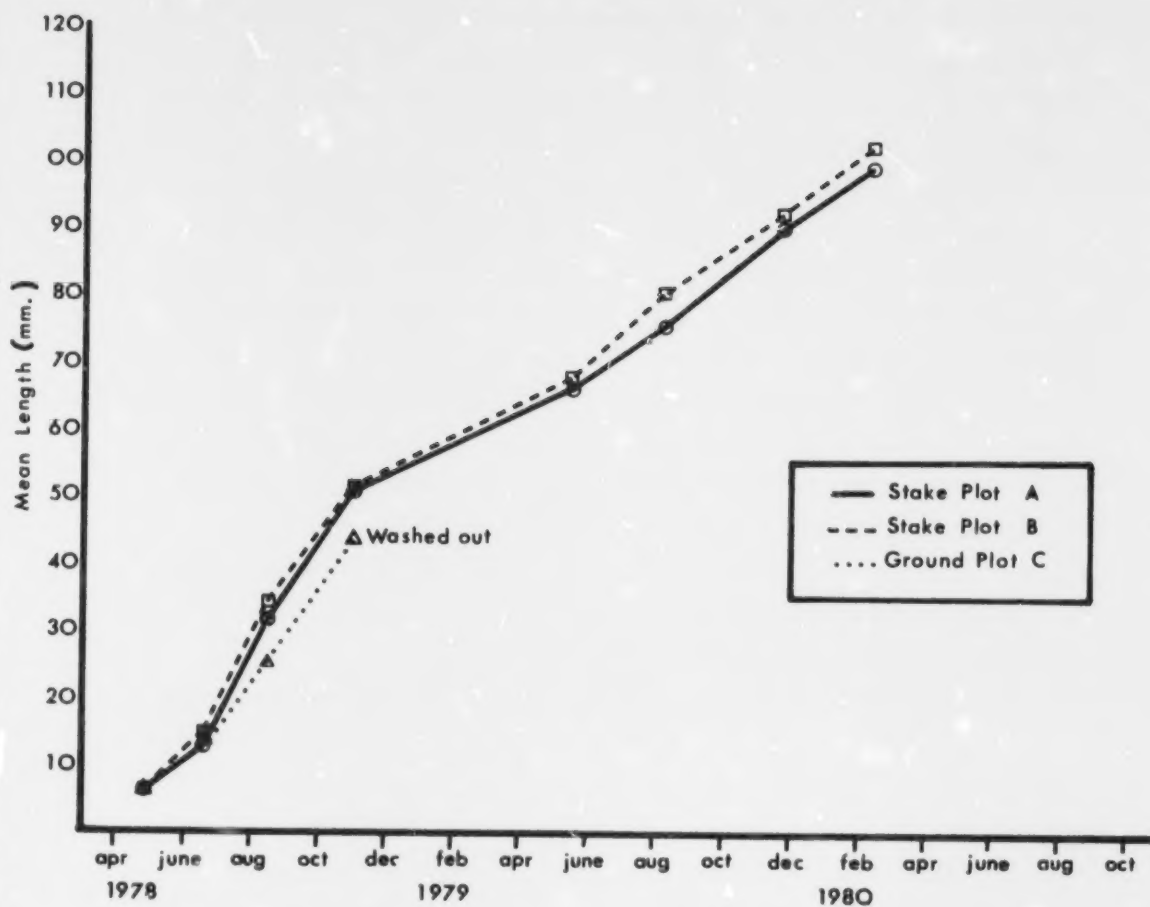
As can be seen, the growth of stake cultured oysters occurs year round at both tide levels, but it is more pronounced in the summer and fall seasons when temperature and food availability are more favourable. Bottom cultured oysters in most areas of the Province do not show this continual growth during the winter (Quayle and Smith, 1976); it is assumed that the increased energy required for sorting out organic from inorganic matter in bottom cultured oysters reduces the available energy for continued growth.

The difference in growth in the upper plot "B" at the 1.3 metre tide level was slightly greater than the lower plot "A". A 2 way ANOVA indicated that growth differences between the two plots is not significant ($P < 0.777$, Figure 7). However, a further analysis of variance of all three plots from April/78 to November/78 indicated that a significant difference exists amongst them ($P < .001$). This can be attributed to the initial slower growth rate of the bottom-cultured oysters as compared to stake-cultured plots.

Table 1. Mean increase in length of shell in mm by sampling intervals. No data is available for the ground plot from May 16/79 to February 12/80 because of "washout".

SAMPLING DATE	MEAN INCREASE IN MILLIMETRES		
	PLOT A	PLOT B	GROUND PLOT
April 27/78	6.5 (BASE LINE DATA)		
June 20/78	8.5	6.5	6.6
Aug. 16/78	19.7	19.1	12.1
Nov. 1/78	16.8	18.8	18.9
May 16/79	16.1	15.0	NO DATA
Aug. 8/79	12.6	9.3	NO DATA
Nov. 21/79	11.9	14.9	NO DATA
Feb. 12/80	10.1	9.4	NO DATA

Figure 7. Mean shell length of oysters grown at two tide levels (upper and lower) between April, 1978, and February, 1980, at Fanny Bay, British Columbia.





MAINTENANCE OF STAKE CULTURE

Stake culture technique requires minimal maintenance. Upkeep activities include stake or cultch replacement and removal of predators.

The number of stakes which were knocked over by floating debris was insignificant. One reason for this is that during periods of high tide most debris would tend to float over the stakes. During periods of low water the stakes would be dry and not susceptible to flotsam. Damage to stakes is, therefore, limited to the time at each tide when the water level is roughly the same height as the stakes. In the early phase of the project, a number of nails which were poorly driven into the stakes fell out, allowing the unattached cultch to be washed away. These problems were quickly overcome as the oysters actually grew onto the nails and stakes within a few months. Table 2 outlines the percentage of cultch or cultch and stakes washed away or knocked down over an 18 month period.

Fouling of the oysters on the stake was heavy at certain times of the year but did not call for mitigative measures to be taken. Organisms responsible for fouling in the Mud Bay area were mussels (*Mytilus edulis*), barnacles (*Balanus glandula*), and sea lettuce (*Ulva* spp.). The mussel and barnacle sets were extremely light in this area and the sea lettuce died off in the summer and regrew in the spring.

The main problem that occurred at Mud Bay was the attack on the cedar stakes by the shipworm (*Bankia setacea*). By harvest time, the stakes had nearly disintegrated. Figure 8 illustrates the extent of destruction which took place in 12 months. The dark portion of the stake was inserted into the substrate and was not affected by the shipworm. By harvest time, the stakes would literally crumble when hit with any force. Since this paper, further work has demonstrated

that treatment of the stakes with a copper based wood preservative extends the life of the stakes. More recent work suggests that stakes constructed of P. V. C. may have a life span of 15 years.

The only predation recorded at this site was from starfish (*Pyconopodia helianthoides*). In this particular case, lone individuals climbed up the stake to feed on the "cluster of oysters". At another stake culture site in Nanoose Bay, very little predation was evident from starfish, although 100% mortality occurred from starfish on a string of oyster seed lying on the ground less than 30 metres from the stake plot. There was also some indication of limited predation of red rock crab (*Cancer productus*) at the Nanoose Bay site.

In Mud Bay, it was sufficient to "walk" the site once a month to pull off starfish, if any, and to replace fallen stakes. (It should be noted that clusters attached to stakes had a significant weight and unlike single oysters, were not moved up the beach by wind and wave action.)

Table 2. Number of cultch and/or stakes washed away or knocked down during study.

	NO. WASHED AWAY	% OF TOTAL WASHED AWAY	NO. DOWN	% OF TOTAL DOWN
PLOT A	78	7.8	132	13.3
PLOT B	111	8.7	148	11.7
PLOT C (GROUND)	ALL	100	N/A	N/A

Figure 8. Destruction of oyster stakes by *Bankia setacea*.

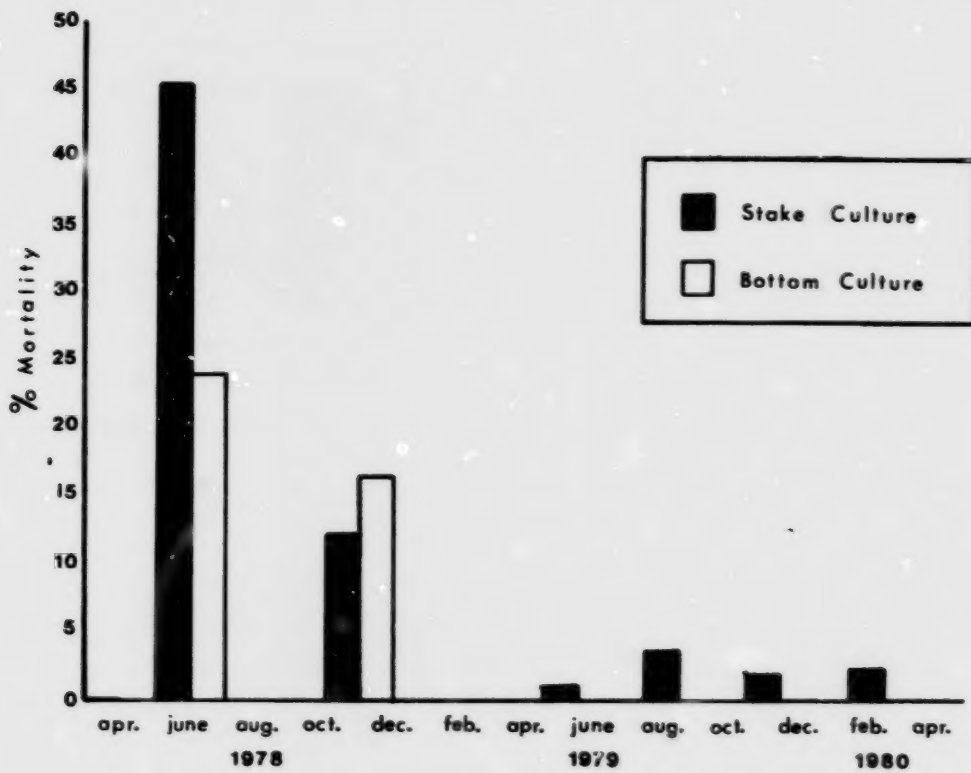


MORTALITY

As illustrated in Figure 9, the mortality rates were highest in the early phase of this experiment. 45.6% of the stake culture population did not survive the first 3 months. After the first 12 months, when the oysters had attained a mean length of 66.8 mm, mortality was negligible. This is visually apparent in Figure 9. The high initial mortality is attributed to intraspecific competition due to the high density of spat/cultch. The mean density of spat/cultch in April, 1978, was 68.3. By the completion of the project in August, 1980, this had dropped to 12.6.

There was no significant difference in mortality between plots "A" and "B" throughout the experiment ($P < .557$). The apparent differences in mortality between the two near-bottom cultures and plot "C" bottom culture prior to the washout of plot "C" is assumed to be a sampling error. Apparently, the seeded cultch used for plot "C" was not randomly selected. Also, the initial number of cultch in plot "C" was small ($N = 10$).

Figure 9. Mean oyster mortality rates of stake and ground plots.



HARVESTING

Fanny Bay Oyster Company utilizes nets for harvesting their oysters. Each net is constructed of used fish net, an iron bar and a rope (Appendix 3). The nets are brought to the site by wheelbarrow or by dropping them at high tide from a barge. At low tide the stakes are pulled up and thrown into a net. One person can fill a net (equal to 7 gallons shucked) in 7 minutes, which is approximately half of the time that it takes to fill a net with beach cultured oysters. The net is "pursed" by a rope which is held by a slip knot. A float is secured to the loose end of the rope. The full nets are picked up by the barge at the next high tide and taken to the shucking house on the nearby foreshore to be emptied into a hopper.

PROCESSING

Stake (and subtidally) cultured oysters are more difficult to shuck than bottom cultured oysters, as the shells are thinner and more easily broken. Stake cultured oysters also tend to form tight "clusters" especially when the number of spat/cultch is high. This also adds to the difficulty of hand shucking. Oysters produced during this project took three times longer to process than traditional bottom cultured oysters. It is assumed this could be changed by:

- (1) using cultch with lower numbers of spat so that more oysters would be individual rather than clustered in one mass; and
- (2) using alternate shucking methods such as those used in Japan.

Steam shucking is one alternative which holds promise and is being investigated further in British Columbia. Under present regulations steam shucked oysters are considered cooked and are suitable for frozen or canned products only.

PRODUCTION

The mean number of oysters per stake upon completion of the growout phase was 12.6 (range of 5 to 21 oysters/cultch). The result of overcrowding led to approximately 60% of the oysters not reaching a marketable size. Table 3 shows the increment volume determined from 20 stakes from each plot. In this determination all oysters were shucked and had a length ranging from 5 mm to 170 mm. Theoretically, with proper spacing of 10 spat/cultch, it is possible that all oysters could be on the maximum end of this range.

These particular oysters were sweeter in flavour and lighter in colour than bottom cultured oysters in the same area. This is more evident in the mud of Clam Bay where noticeable hydrogen sulfide odour is present in the bottom grown oysters but not on the stake cultured ones.

Using the data from Mud Bay based on a mean number of 12.6 oysters per stake at .66 ounces each, one hectare of stake culture (9 stakes/metre) could produce 21,296 litres (1908 gallons/acre) in 22 months*. Most growers, it is assumed, would leave access channels through the stakes. In Clam Bay, for example, the pattern was such that only half of an acre was used. At .66 ounces/oysters, this will yield 10,603 litres per hectare (954 gallons/acre). It is also assumed that most growers, unless using the undersized oysters for smoked, pickled or I. Q. F. products, would replant those under 1 ounce to obtain the marketable size for a fresh product.

An oyster culturist is not limited to planting one cultch per stake. One grower in California has utilized 3-4 cultch per stake (Dahlstrom, unpublished). Many variations are possible and each grower should use whatever method may suit the particular situation.

*One gallon (U. S.) equals 128 or equivalent to 128 oysters/gallon.

Table 3. Volume of meat determined for size classes from each plot.

		SIZE CLASSES (CM)												
		<u>5-6</u>	<u>6-7</u>	<u>7-8</u>	<u>8-9</u>	<u>9-10</u>	<u>10-11</u>	<u>11-12</u>	<u>12-13</u>	<u>13-14</u>	<u>14-15</u>	<u>15-16</u>	<u>16-17</u>	<u>17-18</u>
<u>PLOT A</u>														
NO. OF OYSTERS		3	4	8	35	42	58	60	44	11	1	1	-	1
VOL. (OUNCES)		-	-	-	19	26	40	39	38	12	1	1	-	1.5
$\bar{X}$ VOL.		-	-	-	.54	.62	.69	.65	.86	.91	1.00	1.00	-	1.5
<u>PLOT B</u>														
NO. OF OYSTERS		3	-	9	22	57	59	41	25	8	9	1	-	-
VOL. (OUNCES)		-	-	4.5	11	25	35	28	20	8	9	1.5	-	-
$\bar{X}$ VOL.		-	-	.50	.50	.44	.59	.68	.80	1.00	1.00	1.5	-	-

COSTS

The cost of producing a given volume of stake cultured oysters will vary with fluctuations in the price of seed, materials and labour, mortality rates, and the processing method utilized. The cost of producing one gallon of stake cultured oysters unshucked was \$4.33 based on a wage of \$2.75/hour. Fralick (1979) estimated production and harvesting costs of stake cultured oysters to be \$5.84/gallon and of bottom cultured oysters to be \$5.82/gallon based on a more realistic labour cost of \$5.00/hour. If labour costs for this project were raised to \$5.00/hour, production costs would increase to approximately \$4.80/gallon.

Table 4 outlines the cost involved in producing and harvesting stake cultured oysters based on the planting of 16,000 stakes (Clayton, Smith, 1980).

Table 4. Cost to produce and harvest stake cultured oysters.

DESCRIPTION	\$/HECTARE	\$/LITRE-GALLON (US) UNSHUCKED	\$/STAKE
Stakes (cedar)	149.00	0.24-0.90	0.06
Labour (planting)*	99.33	0.16-0.60	0.04
Seed	149.00	0.24-0.90	0.06
Maintenance	49.67	0.08-0.30	0.02
Harvesting (including transportation)	248.33	0.40-1.50	0.10
Lease fees and taxes	4.96	0.01-0.05	----
Total	700.29	1.12-4.23	0.28

* Estimated

NOTE: At this point in the project, members were paid minimum wage of \$2.75/hour.

CONCLUSION

The experimental oyster culture project at Fanny Bay has demonstrated some of the positive and negative aspects of stake culturing for commercial production of Pacific oysters in British Columbia.

Some of the benefits of this near-bottom technique are:

- (1) reduced damage and mortality from silting, beach tumbling, predation, and competition;
- (2) accelerated growth rate;
- (3) lower maintenance;
- (4) improved flavour, odour and colour of meat; and
- (5) decreased harvesting time.

Some of the negative aspects of this technique are the increased overhead in the initial purchase and installation of stakes, and the somewhat slower processing if hand shucking is used.

This study has shown that this near-bottom culture technique is adaptable to the British Columbia coast. The method is simple, inexpensive, and utilizes simple technology. Production cost of \$1.12 per litre (\$4.23/gallon) with possible production of 21,206 litres per hectare (1908 gallons/acre) compares favourably with other methods now used in the Province. It has been demonstrated that marginal foreshore can be used efficiently to increase the oyster industry's productivity and to furnish the market with a preferable product.

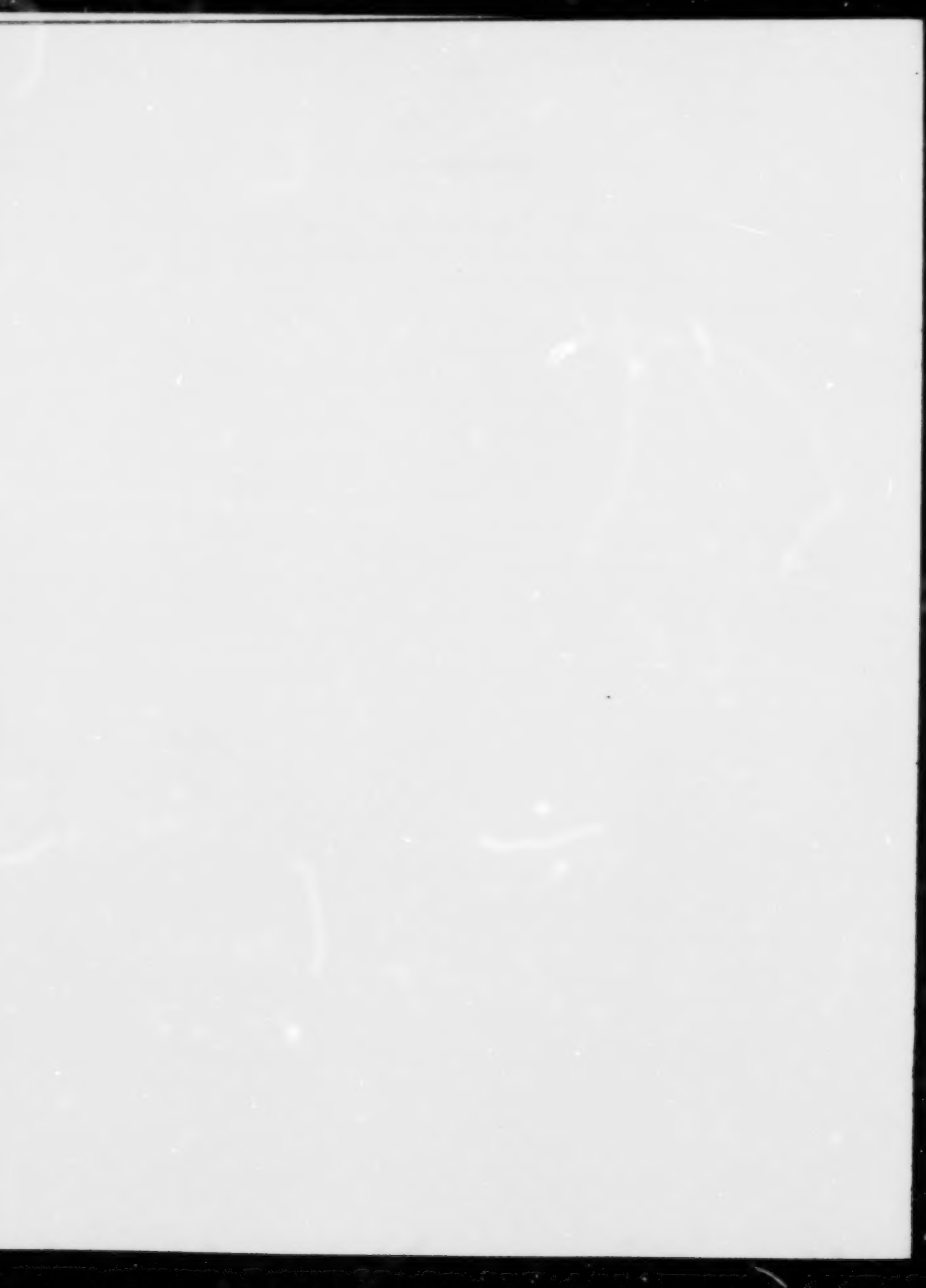
ADDENDUM

Since the project was initiated, four commercial stake projects have been established in marginal areas and two other companies are planning to begin "planting" in the near future. In some of these areas, stake cultured oysters have reached a mean wet weight of 1.3 ounces/oyster after 20 months of growth in spite of two heavy attacks by barnacles (*Balanus glandula*).

Perhaps the most interesting result of this project is the overall enthusiasm which has been stimulated concerning the use of off bottom techniques for oyster culture, including umbrella and rack methods.

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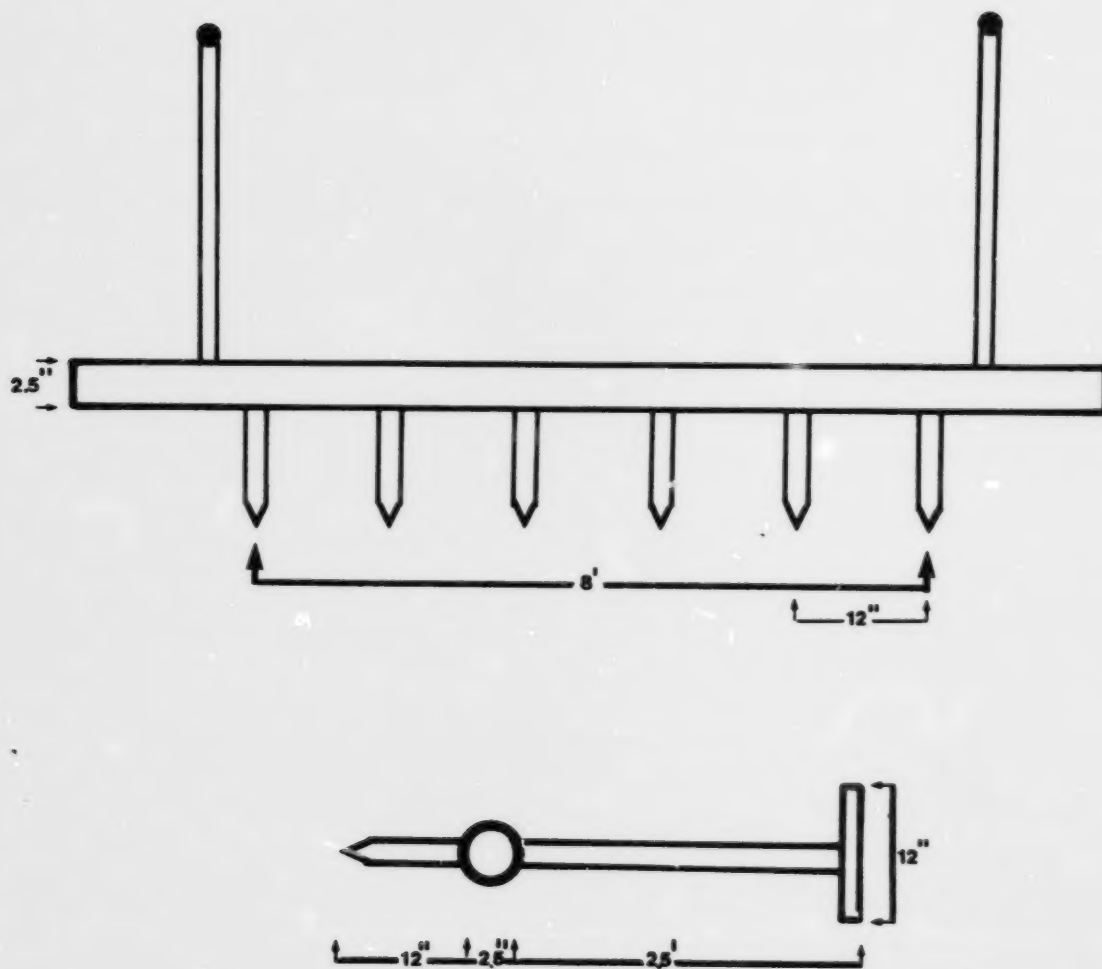
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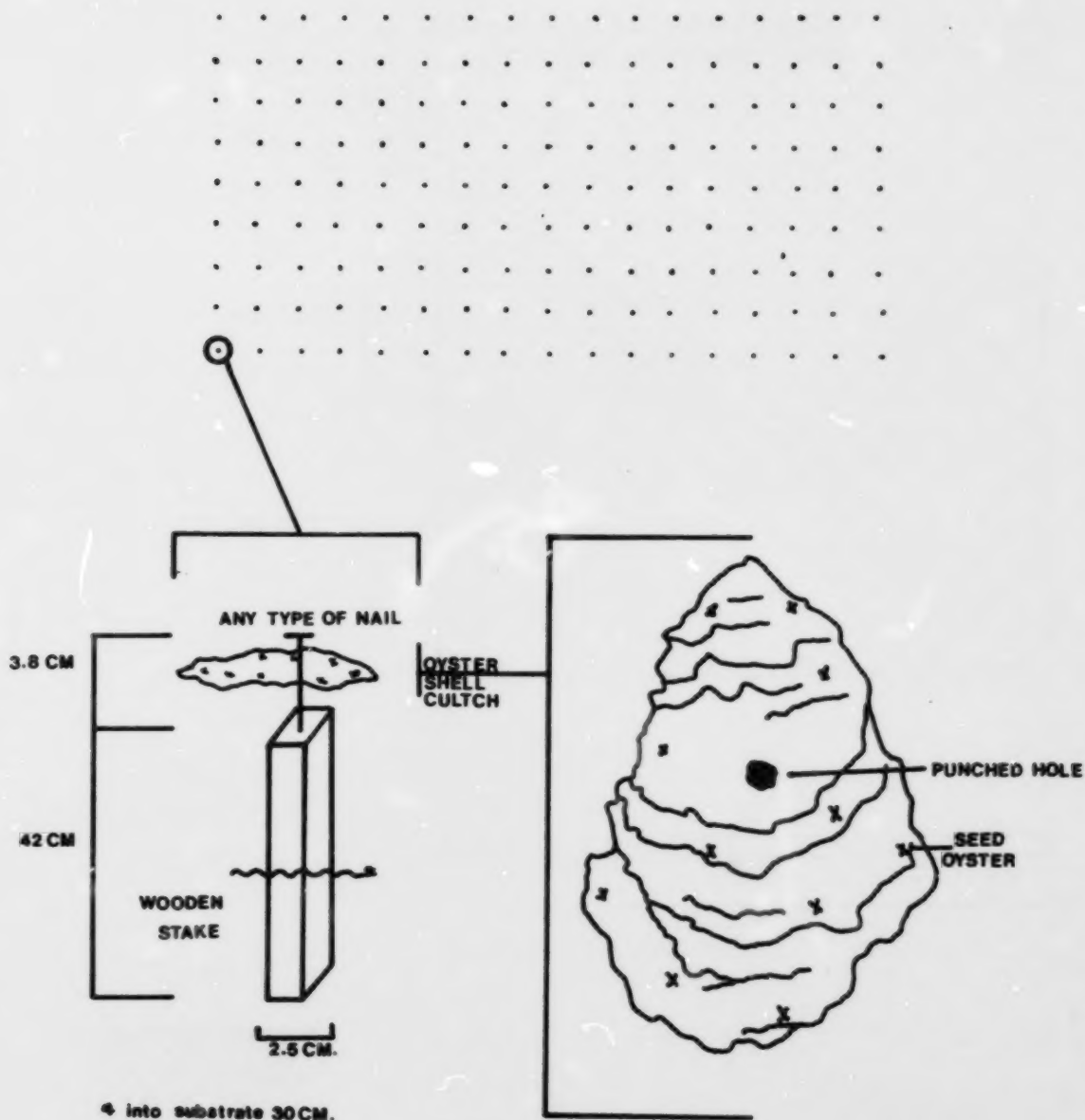
APPENDICES

- I. Stake Hole Puncher
- II. Stake Culture Design Planting Grid
- III. Nets Used (by Fanny Bany Oyster Company) to Harvest Oysters

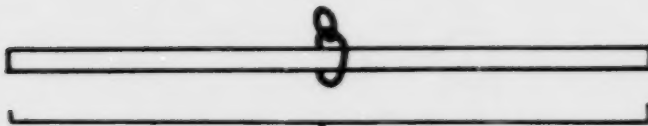
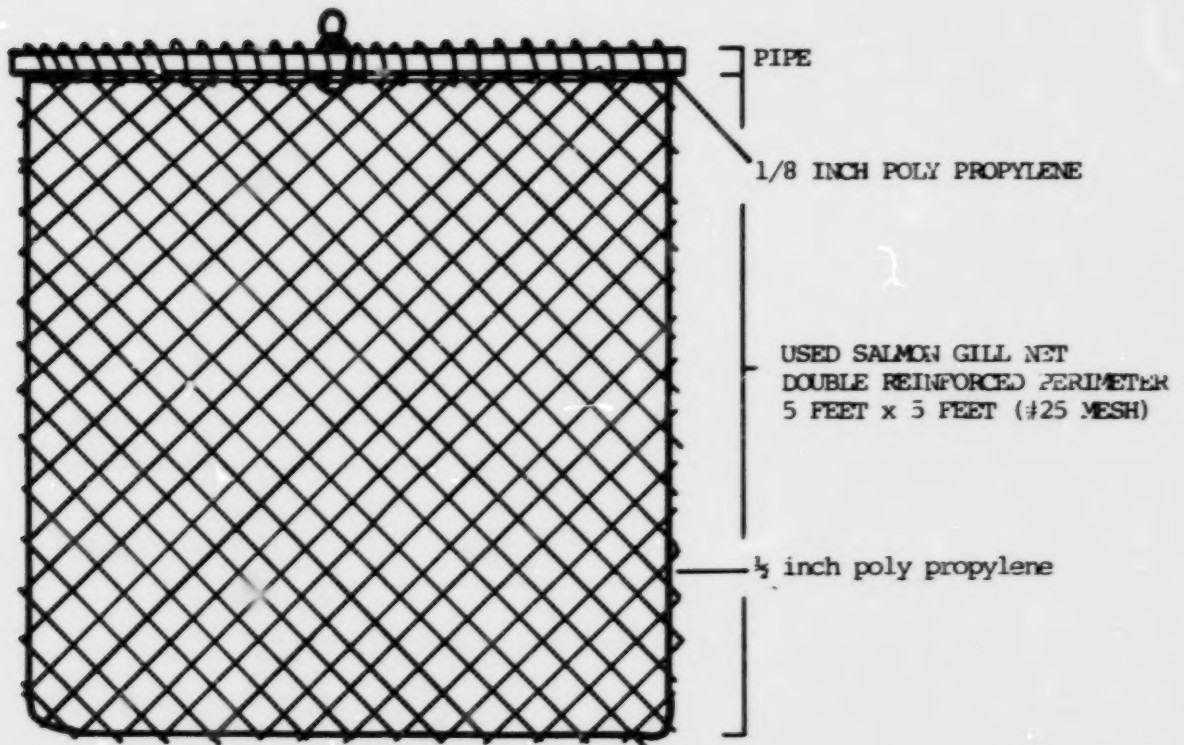
Appendix I. Stake Hole Puncher made out of iron.



Appendix II. Grid layout for planting the experimental stake culture plot in Fanny Bay; details of stakes used; and position of cultch on stake.



Appendix III. Nets used (by Fanny Bay Oyster Co.) to harvest oysters.



5 FEET OF 2 1/2 INCH GALVANIZED PIPE



net filled with oysters and "pursed"